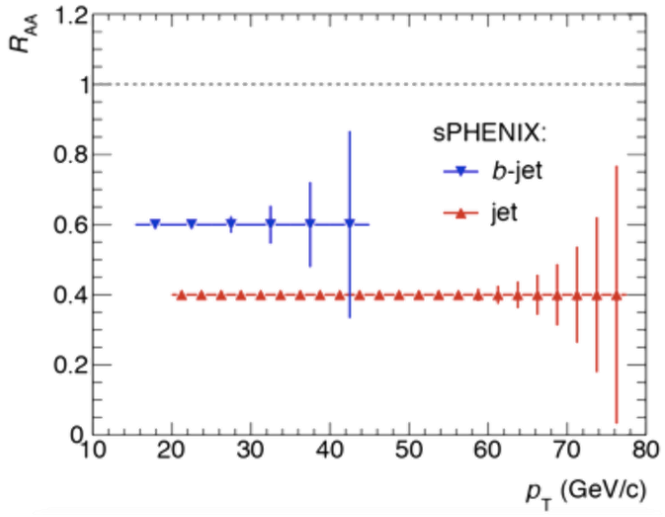
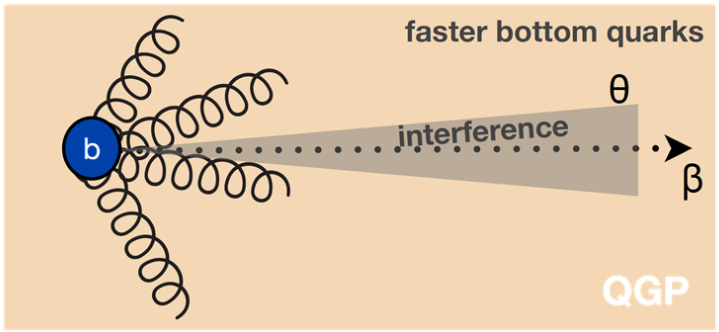
HF Jet Topical Group Report

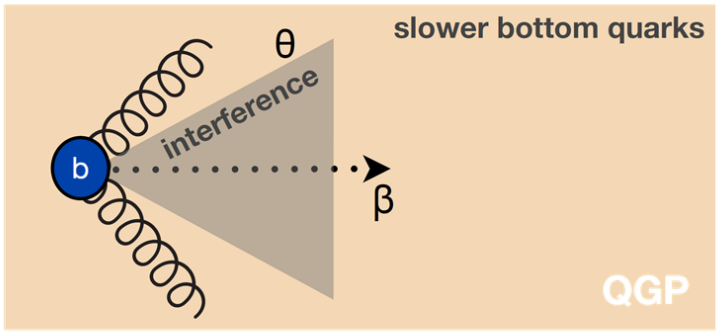
Introduction • Status • Pre-collaboration meeting • Task updates • Summary

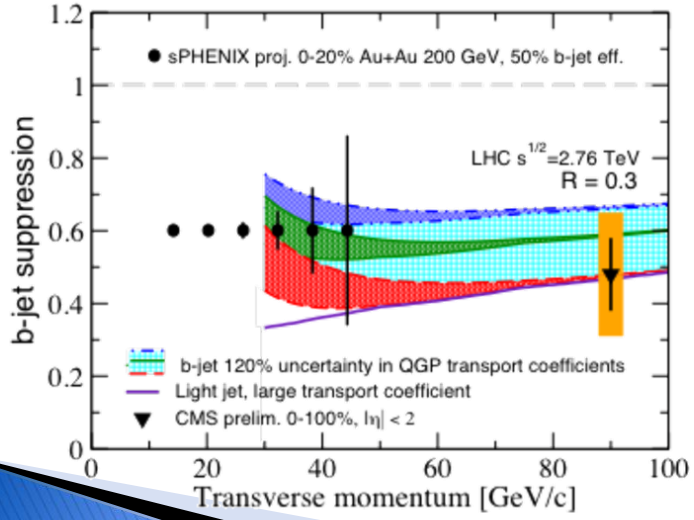
Mike McCumber (LANL)
Jin Huang (BNL)

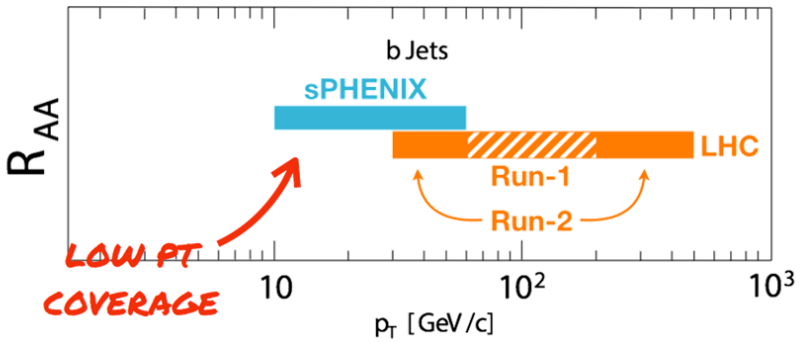
B-tagged jets in sPHENIX









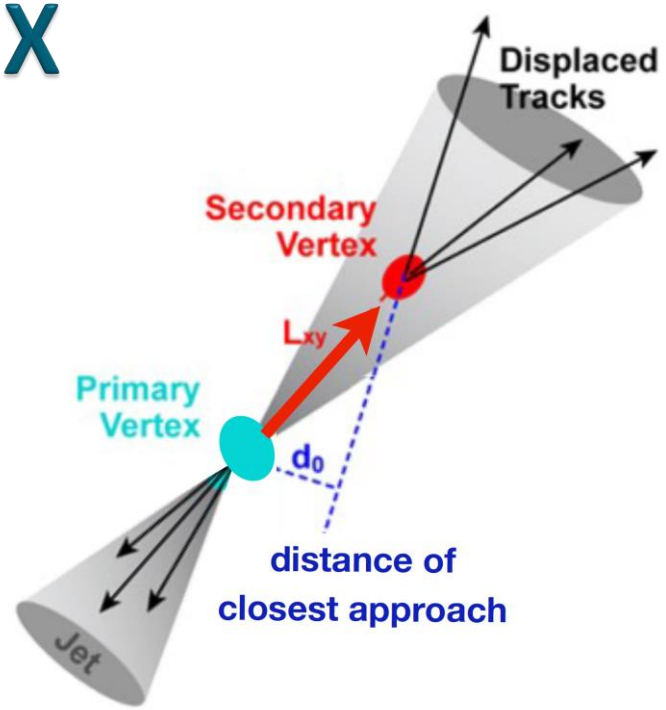


Tagging B-jets in sPHENIX

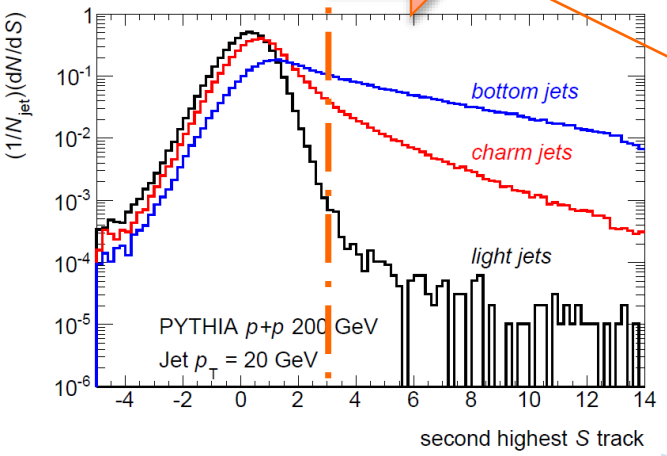
Exploring three methods for sPHENIX B-jets identification and crosscheck

- Multiple large DCA tracks
- Secondary vertex mass
- B-meson tagging via semi-leptonic decay or direct invariant mass reconstruction

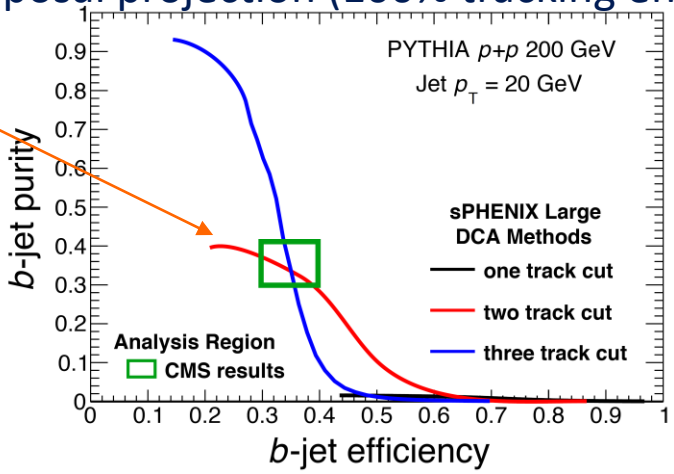
Leads to priority tasks of convincing tracking simulation and b-tagging analysis tools



Cut



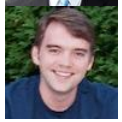
MIE-proposal projection (100% tracking eff. assumed)



Topical group organization

- Co-convener

Jin Huang (Brookhaven National Lab)
<jhuang@bnl.gov>



Mike McCumber (Los Alamos National Lab)
<mccumber@bnl.gov>

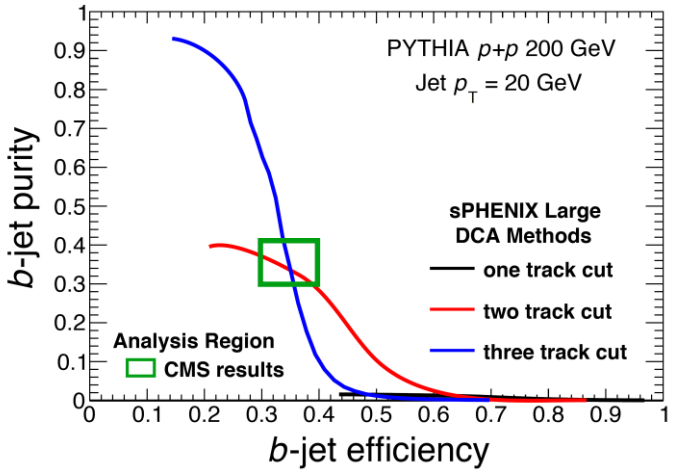
- We are very fortune to have a diligent team working on a wide spectrum of high-priority development (more in later of these slides)
- More manpower are always welcomed and needed!
- Discussion list:
  https://lists.bnl.gov/mailman/listinfo/sphenix-hf-jets-l
- Meetings
  - Use weekly simulation/detector meetings for updates, as many high-priority tasks involve software developments with tracking detector designs
  - Goal oriented irregular events:
    - Initial TG meeting on Apr 22
    - First work-fest on May 16-17

High priority longer-term tasks

- Goal: realistic study of HF jet performance in sPHENIX simulation and reconstruction.
- Target time scale: tracking review
- High priority development tasks (help wanted):
  - Realistic implementation in Geant4
    - Tony F./Gaku M./Chris P., lots of progress
  - Generalized Kalman filter
    - Haiwang Y./Chris P., close to completion
  - Multi-vertexing/B-tagging via secondary vertexing in jet
    - Sanghoon L./Haiwang Y.: exploring RAVE option
  - B-jet tagging: Track Counting
    - Dennis P.: lots of progress in past weeks
  - B-jet tagging: Soft Lepton Tagging
    - Jin H. (+ Help)
  - B-jet tagging: B-Meson Tagging
    - Volunteer needed!

Topical group status/ Tasks for response to ALD charge

- HF-jet tagging heavily relying on DCA capability. Not all scenario require simulation.
- Specific simulation tasks for next two weeks as part of response to ALD charge:
- DCA counting B-tagging efficiency
  - Mike M./Tony Frawley/Sourav Tarafdar: Tracker-only simulation in G4 for few scenarios
    – First batch results ready (see Tony's talk)
  - Dennis P: Fast simulation to produce a purity vs efficiency curve
    – Ready to run
  - Expect results in days. Construct statement in ALD charge
- Lepton tagging with electron near jets
  - Jin: Geant4 parameterized electron-ID performance in two EMCal scenarios
    - DONE
  - 2x2 ganging has minimal impact for electron-HF-jet tagging in p+p collision.

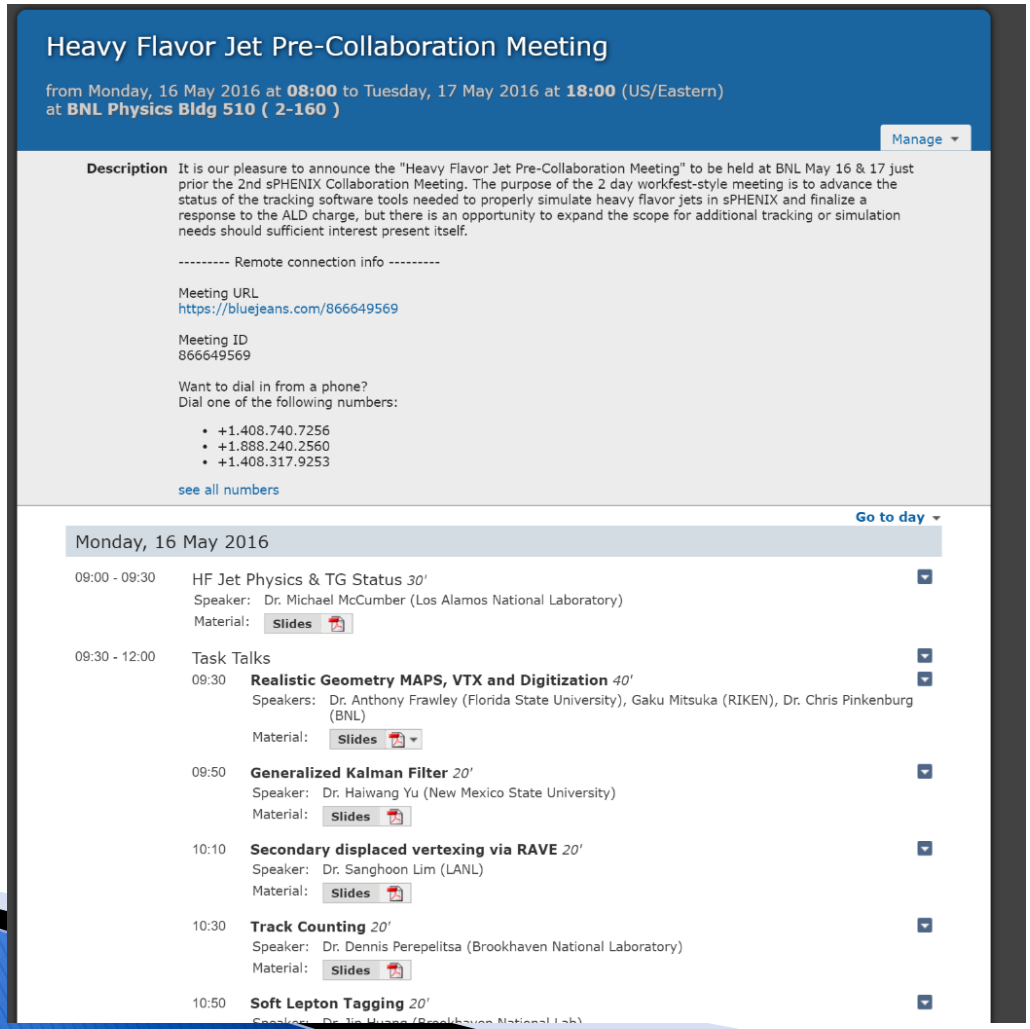


Heavy Flavor Jet Pre-Collaboration Meeting (May 16-17)

- Just finished before the collaboration meeting
- Goal driven TG events:
  - Emergency: recover tracking simulation
    - Mike & Chris: solved a major bug related to update of an external package (Eigen) – Fix available on RCF
    - Sourav & Mike (in contact with Alan): smeared TPC simulation in HIJING still not working (in finite CPU-time), Alan checking. Proceed with simulation @ multiplicity of p+p
  - Short-term: ALD charge study
  - Long-term: High priority long-term developments (see later slides)

Heavy Flavor Jet Pre-Collaboration Meeting (May 16-17)

- https://indico.bnl.gov/conferenceDisplay.py?confId=2077



Heavy Flavor Jet Pre-Collaboration Meeting

from Monday, 16 May 2016 at **08:00** to Tuesday, 17 May 2016 at **18:00** (US/Eastern)
at **BNL Physics Bldg 510 (2-160)**

Manage

Description It is our pleasure to announce the "Heavy Flavor Jet Pre-Collaboration Meeting" to be held at BNL May 16 & 17 just prior the 2nd sPHENIX Collaboration Meeting. The purpose of the 2 day workfest-style meeting is to advance the status of the tracking software tools needed to properly simulate heavy flavor jets in sPHENIX and finalize a response to the ALD charge, but there is an opportunity to expand the scope for additional tracking or simulation needs should sufficient interest present itself.

--------- Remote connection info ---------

Meeting URL
https://bluejeans.com/866649569

Meeting ID
866649569

Want to dial in from a phone?
Dial one of the following numbers:

- +1.408.740.7256
- +1.888.240.2560
- +1.408.317.9253

see all numbers

Go to day

Monday, 16 May 2016

09:00 - 09:30 HF Jet Physics & TG Status *30'*
Speaker: Dr. Michael McCumber (Los Alamos National Laboratory)
Material: Slides

09:30 - 12:00 Task Talks

09:30 **Realistic Geometry MAPS, VTX and Digitization** *40'*
Speakers: Dr. Anthony Frawley (Florida State University), Gaku Mitsuka (RIKEN), Dr. Chris Pinkenburg (BNL)
Material: Slides

09:50 **Generalized Kalman Filter** *20'*
Speaker: Dr. Haiwang Yu (New Mexico State University)
Material: Slides

10:10 **Secondary displaced vertexing via RAVE** *20'*
Speaker: Dr. Sanghoon Lim (LANL)
Material: Slides

10:30 **Track Counting** *20'*
Speaker: Dr. Dennis Perepelitsa (Brookhaven National Laboratory)
Material: Slides

10:50 **Soft Lepton Tagging** *20'*

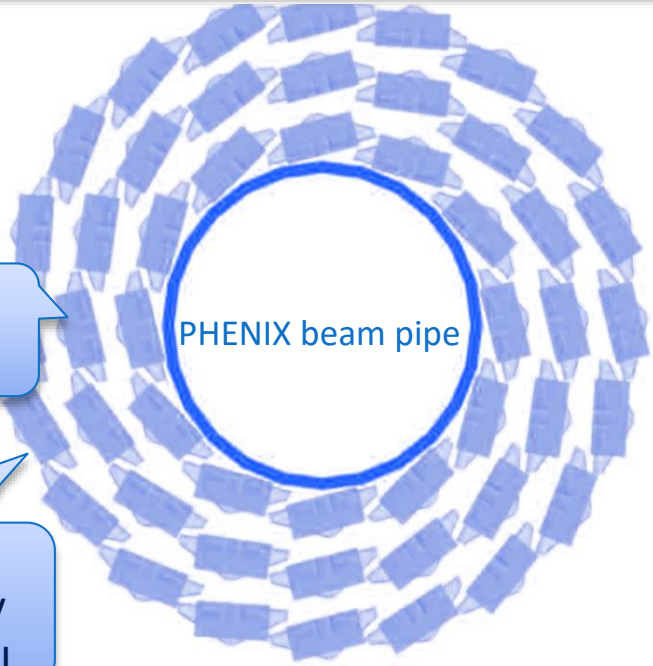
Heavy Flavor Jet Pre-Collaboration Meeting (May 16-17)

- Day-one in-person participants:
  Gaku (RIKEN), Mike (LANL), Haiwang (NMSU), Sourav (Vanderbilt), Weizhuang (Vanderbilt), Chen (NMSU), Xiaorong (NMSU), Kurt (UC/B), Sanghoon (LANL), Chris (BNL), Jin (BNL), Sasha (Weizmann), Dave (BNL), Tony (FSU), Dennis (BNL), Martin (BNL)
- Day-two work-session progress reports:

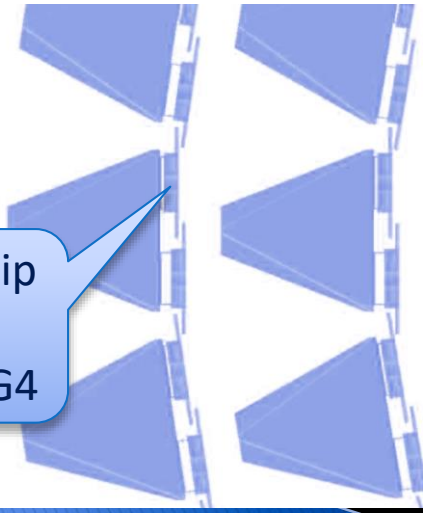
High priority development – Realistic sim. vertex tracker / MAPS

- Mike M. acquired ALICE MAPS geometry model (ROOT/TGeo)
- 2016 MAPS workfest: Imported geometry in sPHENIX simulation by Tony Frawley (FSU), Kun Liu (LANL), Darren
- Development preview: https://github.com/adfrawley/coresoftware/tree/ITS_MAPS_development
- On-going: digitization and interface to tracking (Tony, Chris, Mike, Haiwang)

MAPS Inner tracker in sPHENIX simulation



Stave layout follow sPHENIX demands

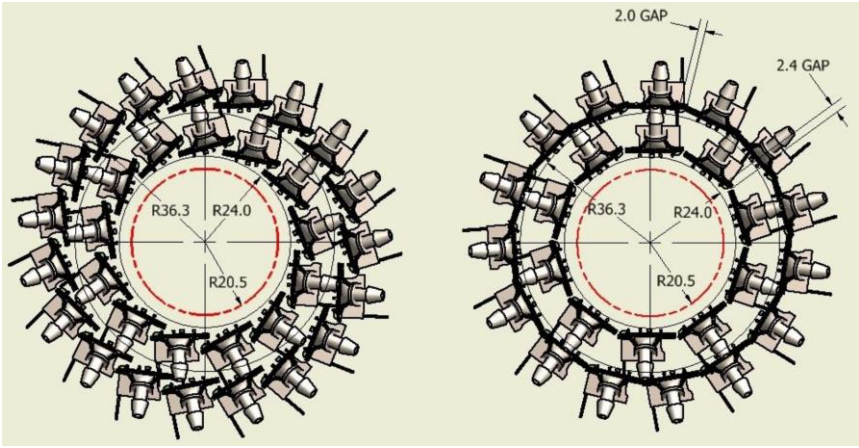


Outer ITS chip & support in sPHENIX G4

Stave geometry simulated in details by importing ALICE model

High priority development – Realistic sim. vertex tracker / VTX

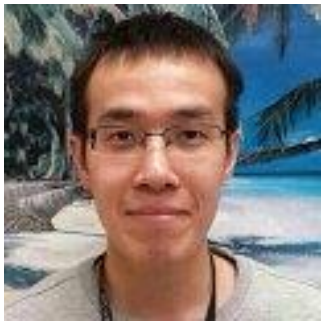
- Gaku Mitsuka (RIKEN) is implementing ladder geometry and tracker design in Geant4
- Plan to use similar approach as MAPS (import stave model, layout in sPHENIX software, digitization and interface to tracking)
- Plan to import VTX pixel stave geometry from PHENIX VTX simulation (developed by LANL group, frequently used by PHENIX G3->G4 simulation)
- Digitization share development with MAPS effort



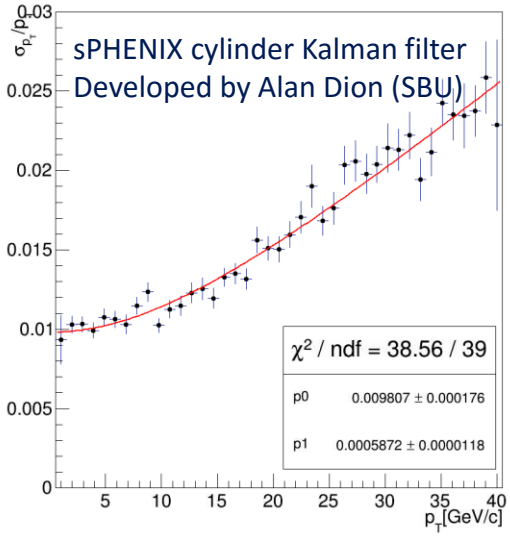
Stave layouts proposed by Rachid Nouicer (BNL)

High priority development – Generic Kalman Filter

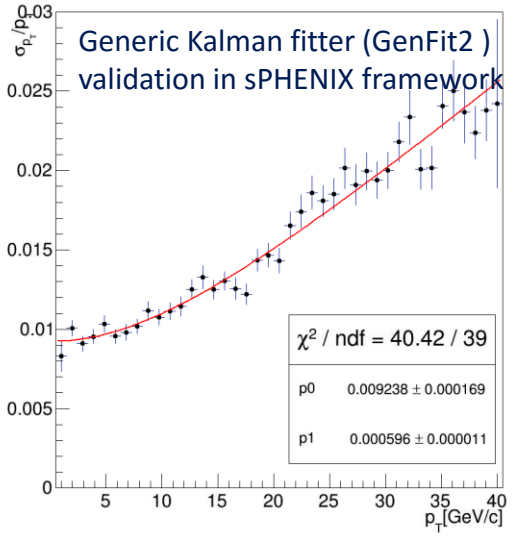
- sPHENIX default Kalman fitter assumed cylindrical tracker. Realistic
- Haiwang Yu (NMSU), with help from Chris Pinkenburg, implemented Bell-II generic purpose Kalman filter (GenFit2) in sPHENIX software: https://github.com/sPHENIX-Collaboration/coresoftware/pull/151
- Next: final validation on-going, expect officialize soon



Alan: σ_{p_T}/p_T

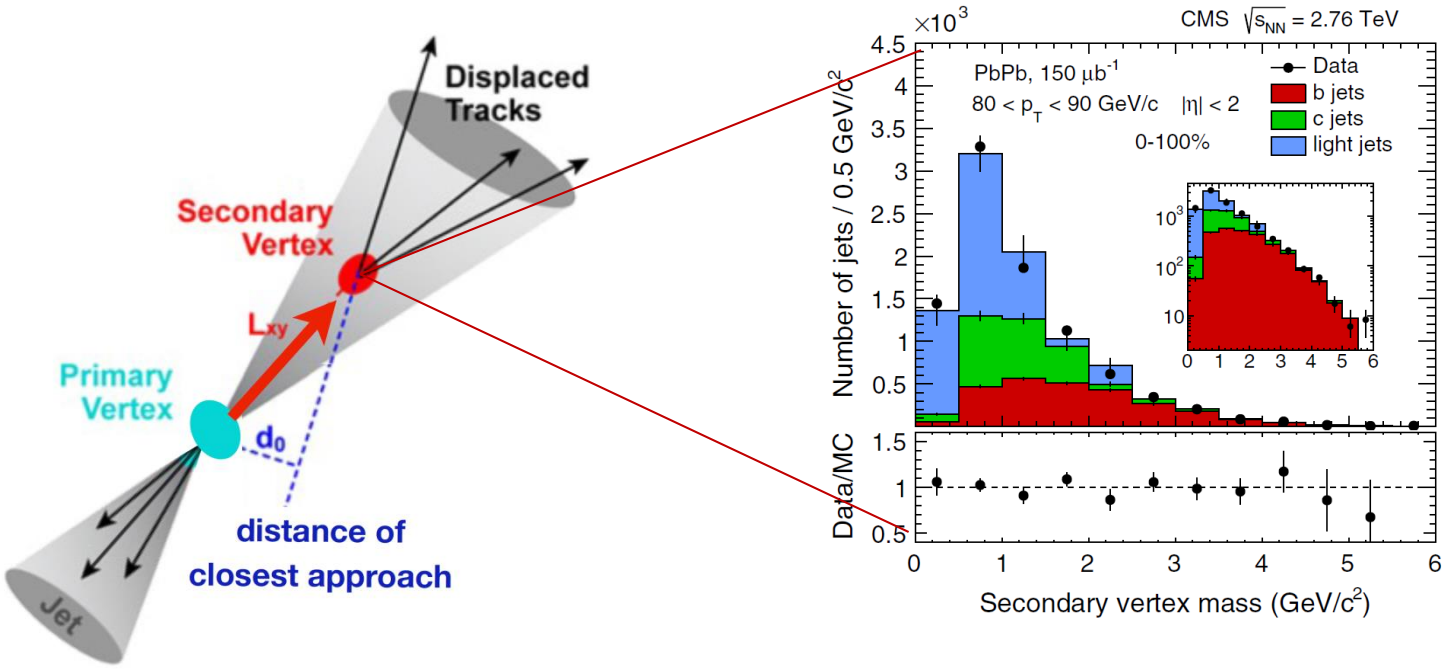


GenFit: σ_{p_T}/p_T



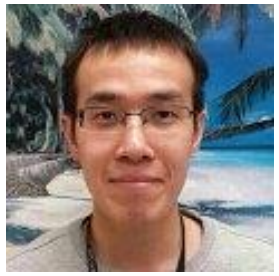
High priority development – Secondary vertex finding in jets

- One leading B-tagging tool require identify the higher-inv-mass secondary decay vertex
- Require proper tool to identify secondary vertex in jet
  - GenFit2 tool also interface to multi-vertex finder: RAVE

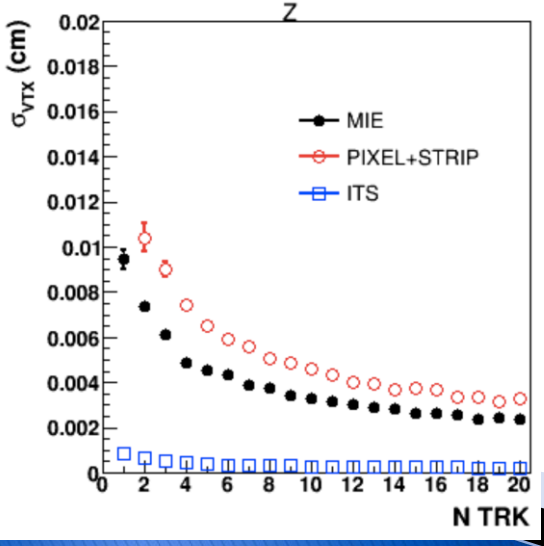


High priority development – Secondary vertex finding in jets

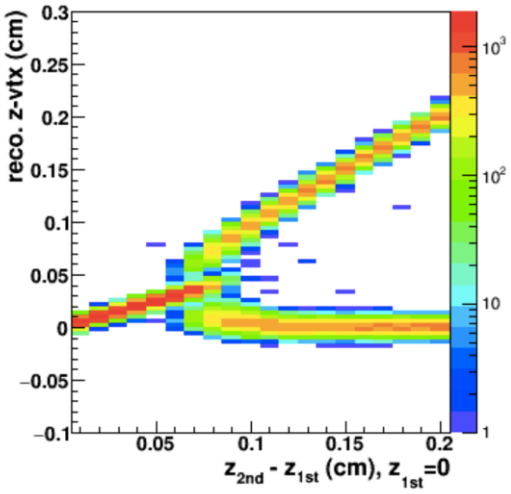
- Sanghoon Lim (LANL) and Haiwang Yu (NMSU) are exploring use of RAVE for sPHENIX vertexing
- Initial validation of multi-vertex separation with sPHENIX simulation is promising
- Next step: test in full Pythia event in full sPHENIX tracker simulation



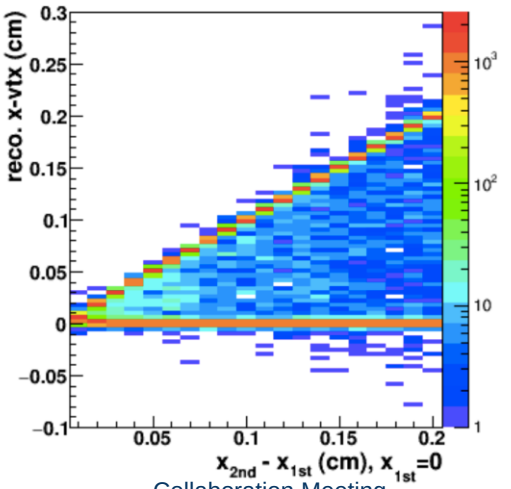
Single input vertex
compare 3-tracking config.



Two input vertex
Z-separation capability

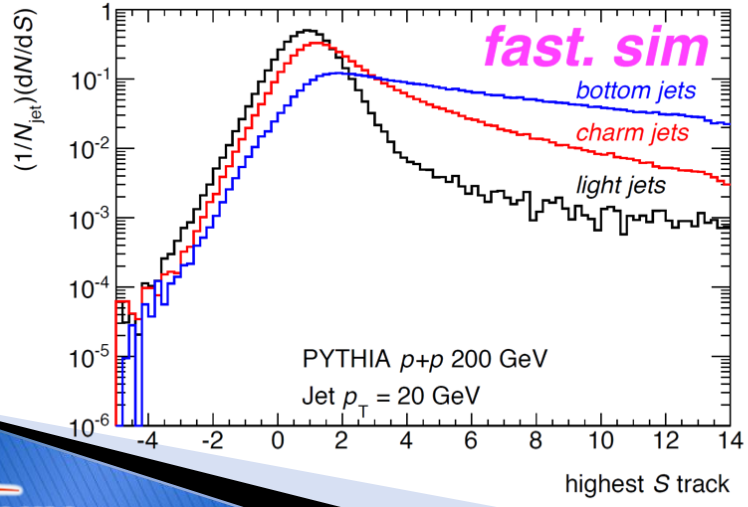


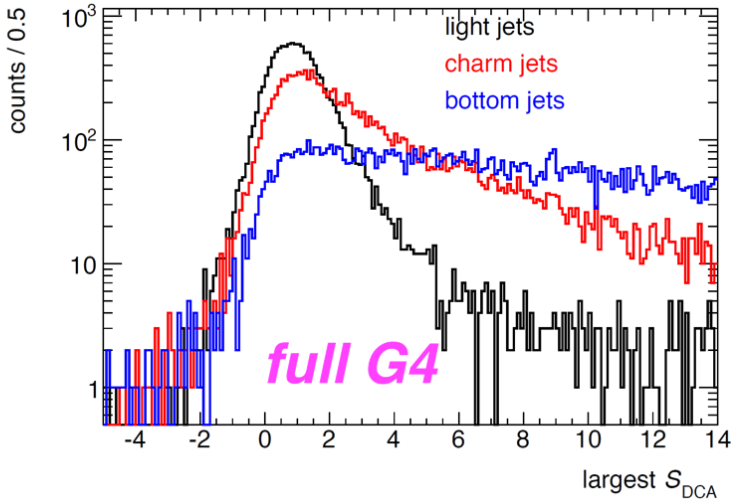
Two input vertex
X-separation capability



B-jet tagging – High DCA track counting

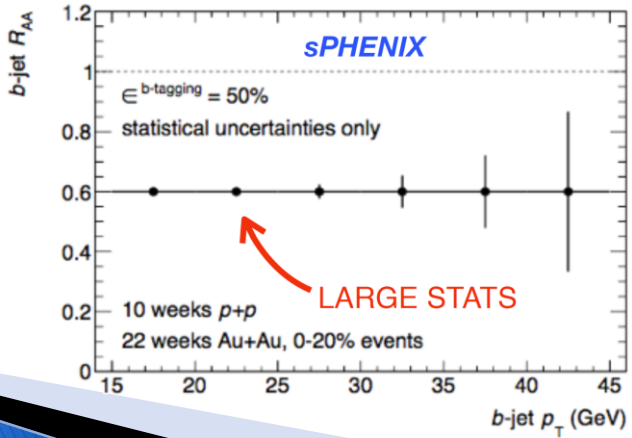
- The current operating B-jet tagger for sPHENIX is developed by Dennis Perepelitsa (BNL) based on significant-DCA track counting method
- Geant4-parametrized fast simulation has been developed for sPHENIX MIE proposal. Plan to reuse for ALD charge study
- Full-Geant4 tracker simulation are in develop by Dennis
- Plan: validate full Geant4 tagging software and make it official tool for DCA-counting method

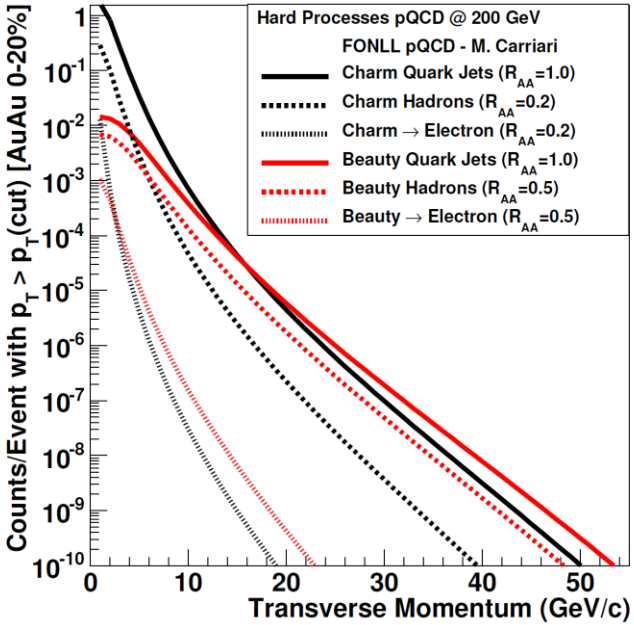




B-jet tagging – Decay lepton tagging

- None-photonic lepton has been a successful tool in studying heavy quark behavior in QGP
- Given a jet detected, lepton tagging in or near the jet cone could enhance HF jet fraction due to larger fraction of B(->d)->e decay than h->e decays.
  - Benefit:
    - Not necessarily require a DCA capability. No additional sPHENIX detector required
    - (Largely) orthogonal to and cross check life-time-based B tagging: e.g. DCA-track-counting and Secondary vertex mass methods
  - Cost: B->e branching ratio (~20%), electron identification efficiency, (b-tagging efficiency)
- Challenge:
  - Exploring possibility @ RHIC energy
  - Signal/background ratio and
  - Optimization both in $j_{T,e}$ and DCA_e
  - Statistics

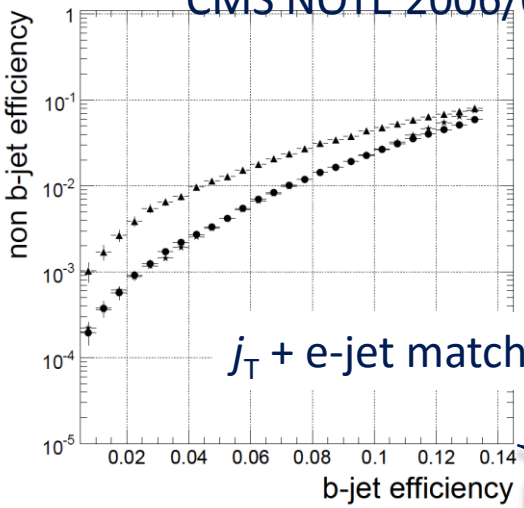




Decay lepton tagging - CMS studies (muon tagging)

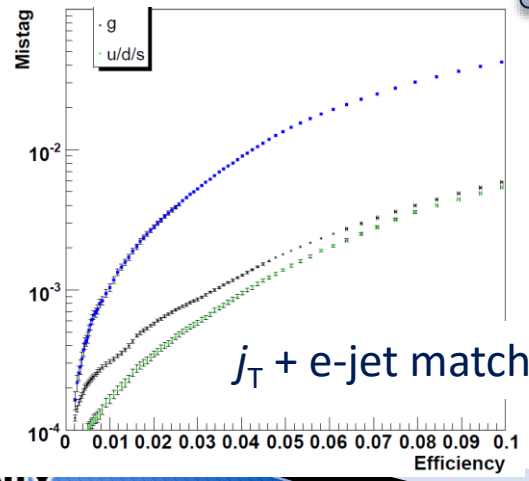
Rejection VS tagging eff.

CMS NOTE 2006/043



j_T + e-jet matching + DCA_e

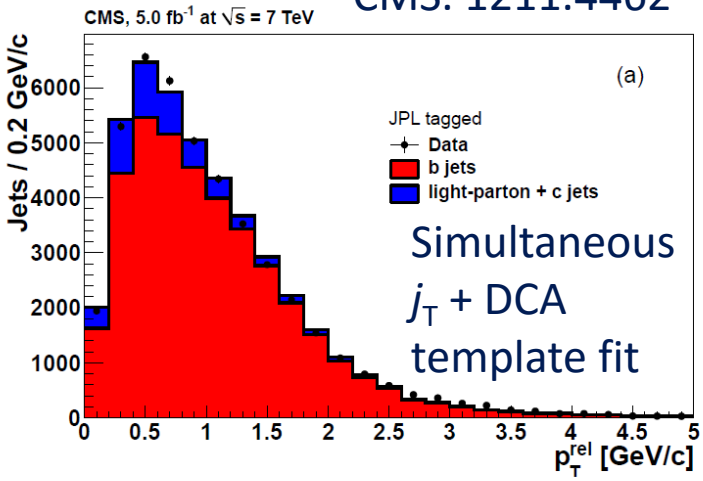
Suffer of B->μ BR



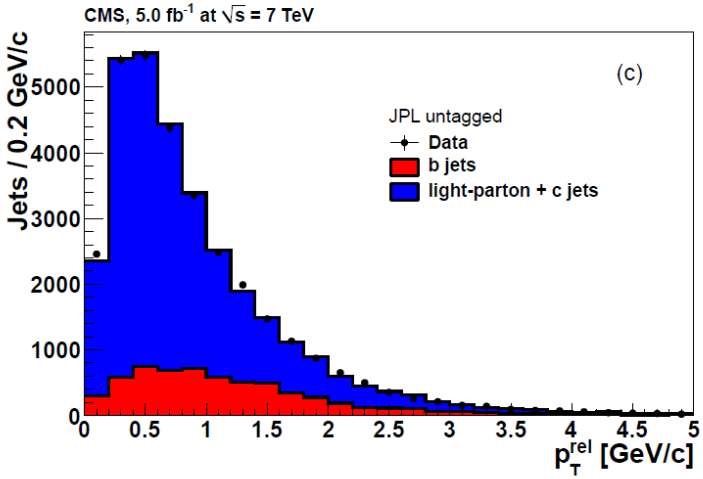
j_T + e-jet matching ~~no DCA_e~~

As cross check to JP/L method

CMS. 1211.4462



Simultaneous j_T + DCA template fit



Decay lepton tagging – Electron ID in sPHENIX

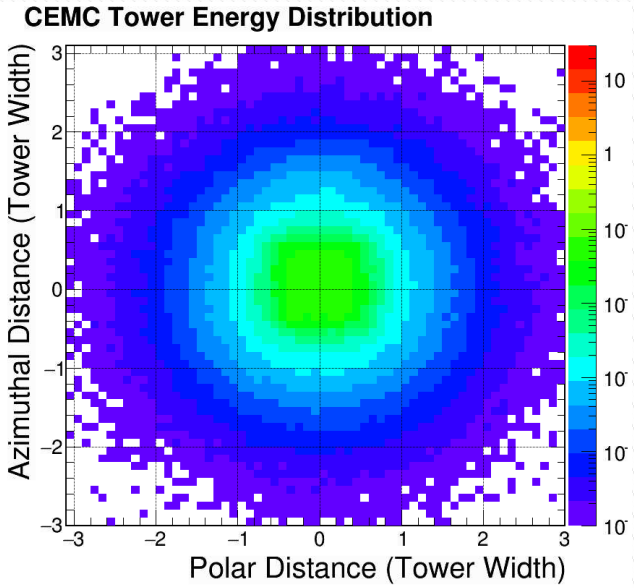
- Choice of electron leads to difference background than muons
- sPHENIX use EMCal + inner HCal to reject to hadron
  - >100:1 in pp
  - ~100:1 in inclusive tracks in Central 10% AuAu
  - ??:1 for electron candidate near a jet <- to be re-evaluated
- One recent de-scoping option involves reduce scope of the EMCal
  - Reduce readout channel by ganging tower together for readout: expect 2-times impact in central AuAu, minor in p+p
  - Reduce tower count by cut eta coverages: direct reduce of statistics

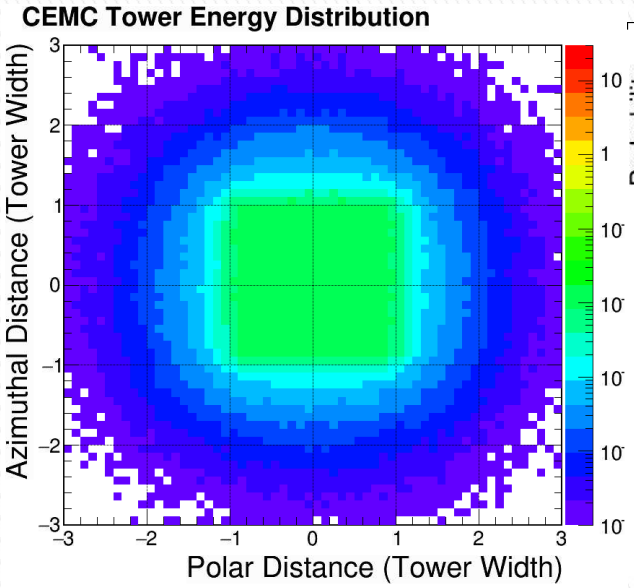
EM-Shower shape as observed in readout

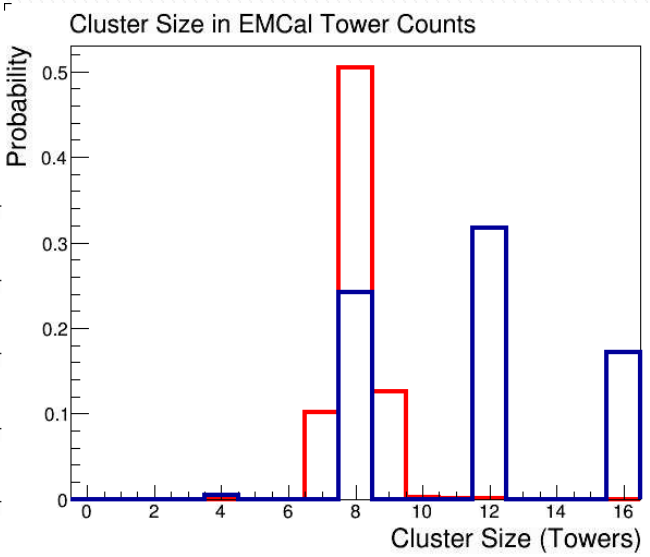
8 GeV e- shower in 2D proj. SPACAL around eta = 0

Larger spread of shower core requires larger cluster to contain, which pickup higher portion of hadronic shower and higher event background

— Default
— 2x2 Ganging







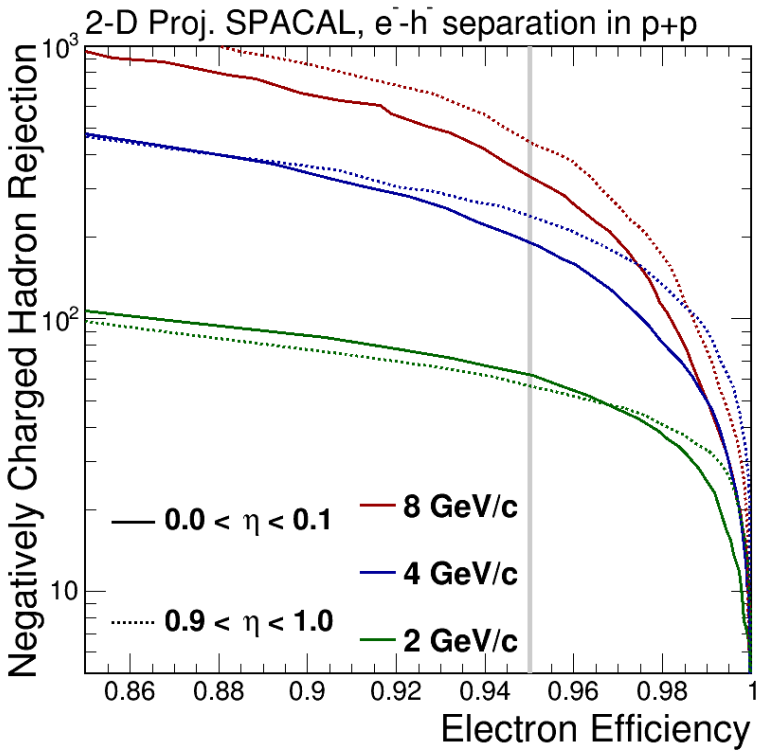
One readout per tower

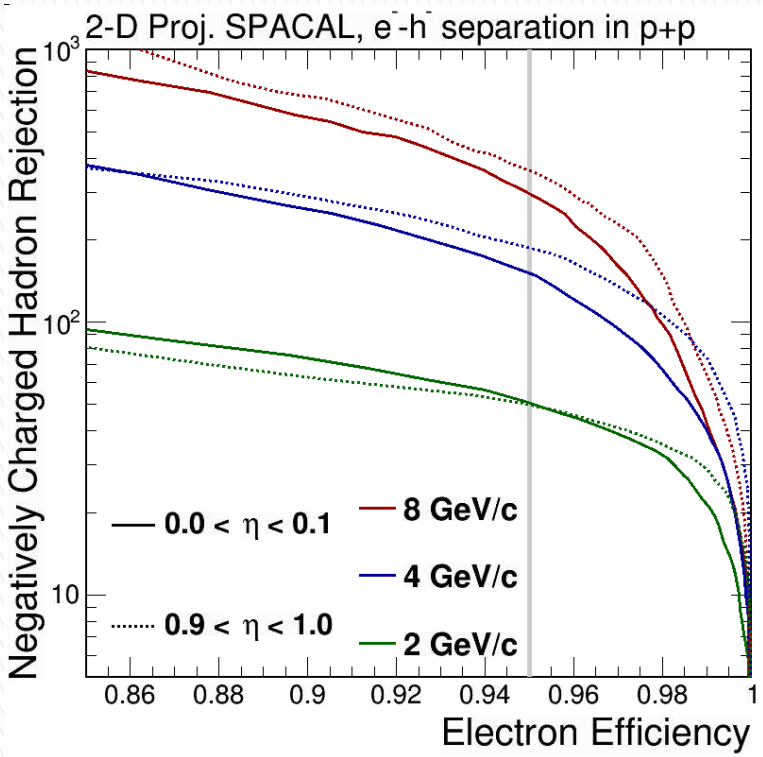
One readout per 2x2 tower

Cluster size comparison

Single Particle Summary: h-

Single negatively charged particle 2/4/8 GeV shower in 2D proj. SPACAL





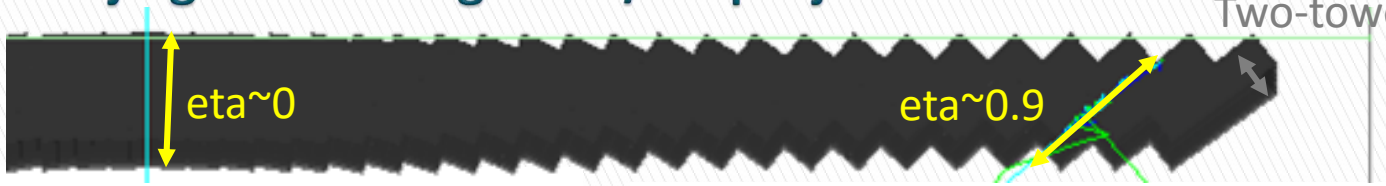
One readout per tower (cost-schedule review)

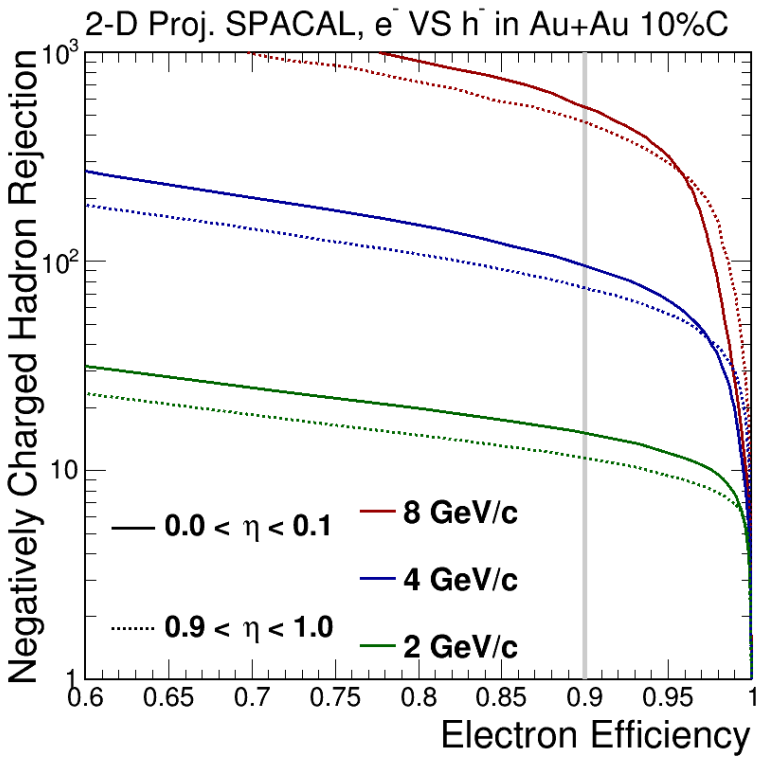
One readout per 2x2 tower Cluster size x (1.2x1.2)

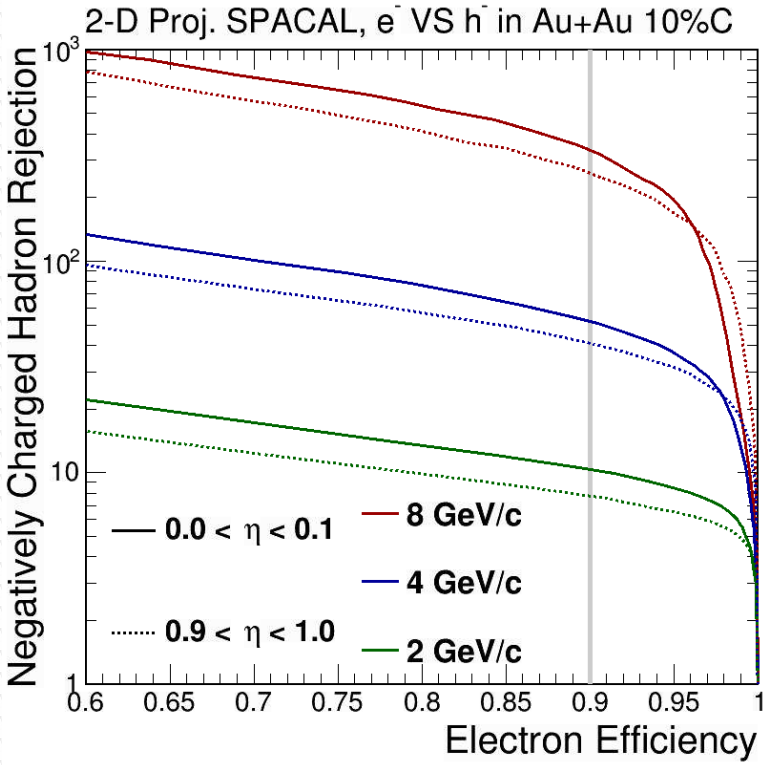
Assuming good tower gain matching in 2x2 ganging

In Hijing –2D SPACAL summary: h-

10% Central Hijing embedding in 1D/2D proj. SPACAL







One readout per tower
(cost-schedule review)

One readout per 2x2 tower
Cluster size x (1.2x1.2)

Assuming good tower gain matching in 2x2 ganging

B-jet tagging – B/D meson tagging

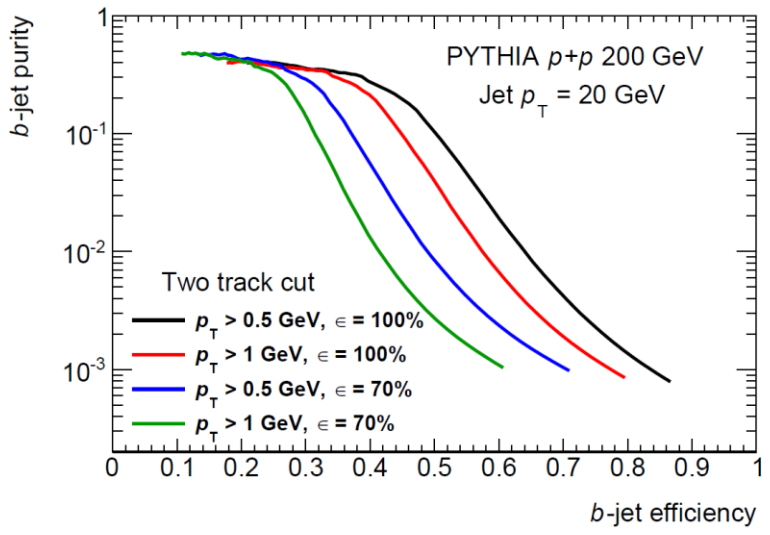
- Enhancing gluon-splitting rejection by requiring a fully reconstructed B/D meson carry large fraction of jet momentum
- Thanks to Sevil Salur raised the point during the first TG meeting
- Need volunteer

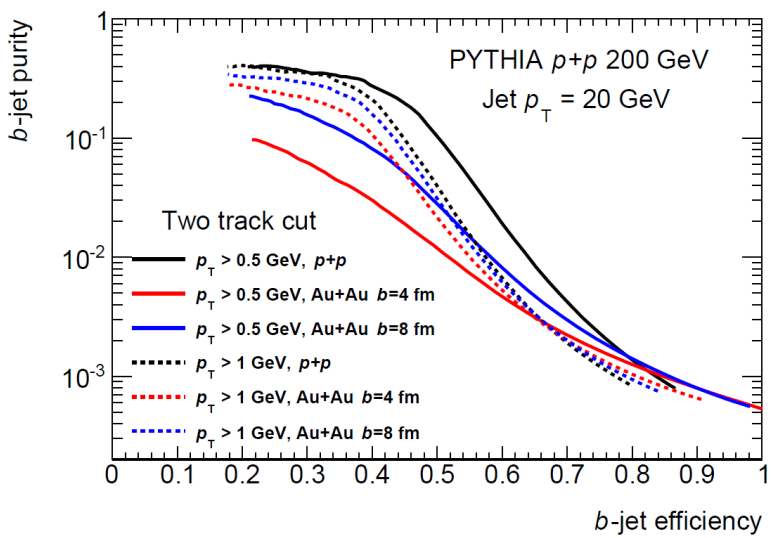
Summary

- B-jet tagging rely on high precision and efficiency tracking. TG organized around convincingly quantify B-tagging performance in full simulation.
- Many progress made towards high priority development tasks (help still wanted):
  - Realistic implementation in Geant4
    - Tony F./Gaku M./Chris P.: G4 geometry done, working on interface to tracking
  - Generalized Kalman filter
    - Haiwang Y./Chris P., close to completion
  - Multi-vertexing/B-tagging via secondary vertexing in jet
    - Sanghoon L./Haiwang Y.: exploring RAVE option
  - B-jet tagging: Track Counting
    - Dennis P.: lots of progress in past weeks
  - B-jet tagging: Soft Lepton Tagging
    - Jin H. : started exploring
  - B-jet tagging: B-Meson Tagging
    - Volunteer needed!
- For ALD charge: constructing jet-tagging efficiency plots, after yesterday fix of the tracking software. Expect results in days.

Extra information

B-tagging VS track efficiency [1501.06197]





Tracking efficiency dependence

Occupancy dependence